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Regional Provenance Trials of Black Spruce in Newfoundland : Fifteen Years from Seed

J. Peter Hall

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ABSTRACT

A provenance trial of black spruce consisting of 28 sources from Newfoundland and nine from mainland Canada was measured when the trees were 15 years old. Survival was high and all provenances appeared to be broadly adapted to all sites. Variation in height growth appeared to be clinal for the island of Newfoundland except for the Northern Peninsula and the Avalon Peninsula. There was a high correlation between height at 10 and 15 years of age. Provenances were identified which were superior over a range of sites and several which were superior in one or two sites.

RÉSUMÉ

Un test de provenance a été appliqué à des épinettes noires provenant de 28 sources à Terre-Neuve et de 9 sources dans la partie continentale du Canada au moment où celles-ci avaient 15 ans. Le taux de survie était élevé et toutes les provenances semblaient généralement adaptées à tous les endroits étudiés. Les variations de la croissance en hauteur semblaient clinales pour l'Île de Terre-Neuve sauf en ce qui touche la péninsule nord et la presqu'Île Avalon. La hauteur était étroitement corrélée à 10 et 15 ans. On a identifié certaines provenances quiétaient supérieures dans un gamme de stations et plusieurs qui l'étaient dans une on deux.

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REGIONAL PROVENANCE TRIALS OF BLACK SPRUCE IN NEWFOUNDLAND: FIFTEEN YEARS FROM SEED

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INTRODUCTION

Black spruce [*Picea mariana* (Mill.) B.S.P.] is a valuable conifer throughout Canada and in Newfoundland is the main species used in reforestation programs. There is an opportunity to enhance forest productivity by ensuring that the best adapted sources are planted and that the most productive seed sources are used (Zobel and Talbert 1984). The examination of natural variation in provenance trials identifies the best sources for a particular environment. Use of the best seed source enhances productivity through better growth rate, improved wood quality and resistance to damaging insects and diseases (Zobel and Talbert 1984).

Studies of inter-provenance variation in other conifers have described quantitative and qualitative variation (Yeatman and Morgenstern 1978). For example in white spruce [*P. glauca* (Moench) Voss], the geographic variation shows that Ottawa Valley seed sources invariably outperform all other sources. In Jack pine (*Pinus banksiana* Lamb.) local sources[1] usually grow fastest but sources from the western Quebec part of the range have an enhanced resistance to disease. For red pine (*P. resinosa* Ait.) there is remarkably little inter-provenance variation

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[1]A 'local' seed source consists of seed which was grown on and collected from the site in question.

compared to that in other conifers. For red spruce (P. rubens Sarg.) the degree of interprovenance variation is related to the degree of introgression with black spruce (Morgenstern et al. 1981).

Provenance studies on black spruce in Canada began in the 1960s. In a trial of mainly Ontario seed sources Morgenstern (1969) demonstrated that variation in height growth was clonal and growth was inversely correlated with latitude. Growth was closely related to ecological factors of the seed origin (day length, temperature, precipitation) suggesting that the best adapted sources were those of local origin. In another study on upland and lowland seed sources it was shown that edaphic ecotypes did not form in black spruce (Fowler and Mullin 1977).

In 1968 a trial of Newfoundland provenances was established. The nursery phase of the study was done over four years and published (Nicholson and Tricco 1969, Khalil 1973). In 1970 seed from these same sources was used to establish plantation trials. This paper presents the results of these plantation trials, 15 years from seed.

METHODS

A total of 37 seed sources was collected for the trials, 28 from Newfoundland and nine from mainland Canada (Appendix I)[2]. Seed was

[2]More detailed information on seed sources and planting sites is given in Khalil (1975).

sown in the Canadian Forestry Service nursery at Pasadena in the spring of 1970. The field trials were established in the spring of 1974 using 2 + 2 stock (Khalil 1975). Not enough seedlings were available for all plantations so the number of provenances tested varied between 15 and 37 (Table 1). Six plantations were established in the major productive forest sections of Newfoundland (Figure 1)(Rowe 1972).

Seedlings were planted by the slit planting method and planting was completed during the period 28 May to 26 June 1974. All plantations were designed as randomized complete blocks with six replicates and four tree linear plots. Spacing was 1.8 metres and a double row of surround trees was planted around each plantation.

The provenances were measured in the fall of 1979 when the trees were 10 years old from seed (Khalil 1981) and again in 1984 when the trees were 15 years old. Total height and diameter at 1.3 m were measured in all plantations.[3] The data were analyzed by standard analysis of variance techniques and range tests were conducted on the means (Steel and Torrie 1960) (Appendix II).

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[3]Mean diameter among the plantations ranged from 0.4 to 2.1 cm. Since many trees were less than 1.3 m tall the diameter data is not included. Variation in diameter showed somewhat similar trends to that of height.

Table 1. List of plantations and provenances planted.

Location	Forest section	Lat.	Long.	Elev. (m)	Provenances planted	Planting dates
Cochrane Pond	B.30	47°28'	52°54'	180	3,4,6,7,10, 13,16,19,20 24,26,28,36, 37,43 (Total 15)	25-26 June
Roddickton	B.29	50°58'	56°13'	100	1-8,10,11,13-28,30-34,36, 37,39,43,44 (Total 36)	20-21 June
Stag Lake (Little George's Lake)	B.28b	48°51'	58°01'	180	3-8,10,13,15, 16,18,19-21, 23-26,28,30, 34,36,37,39, 43,44 (Total 26)	28-29 May
Big Falls	B.28b	49°16'	57°09'	140	3,4,6,7,10, 13,15,16,19, 20-24,26,28, 34,36,37,43, 44 (Total 20)	30-31 May
Sandy Brook	B.28a	48°55'	55°58'	120	1-8,10,11,13-34,36,37,39, 43,44 (Total 37)	10-11 June
New Bay Pond	B.28a	49°06'	55°35'	140	3,4,6,7,10, 13,15,16, 19-21,23,24, 26,28,36,37, 43 (Total 18)	12-13 June

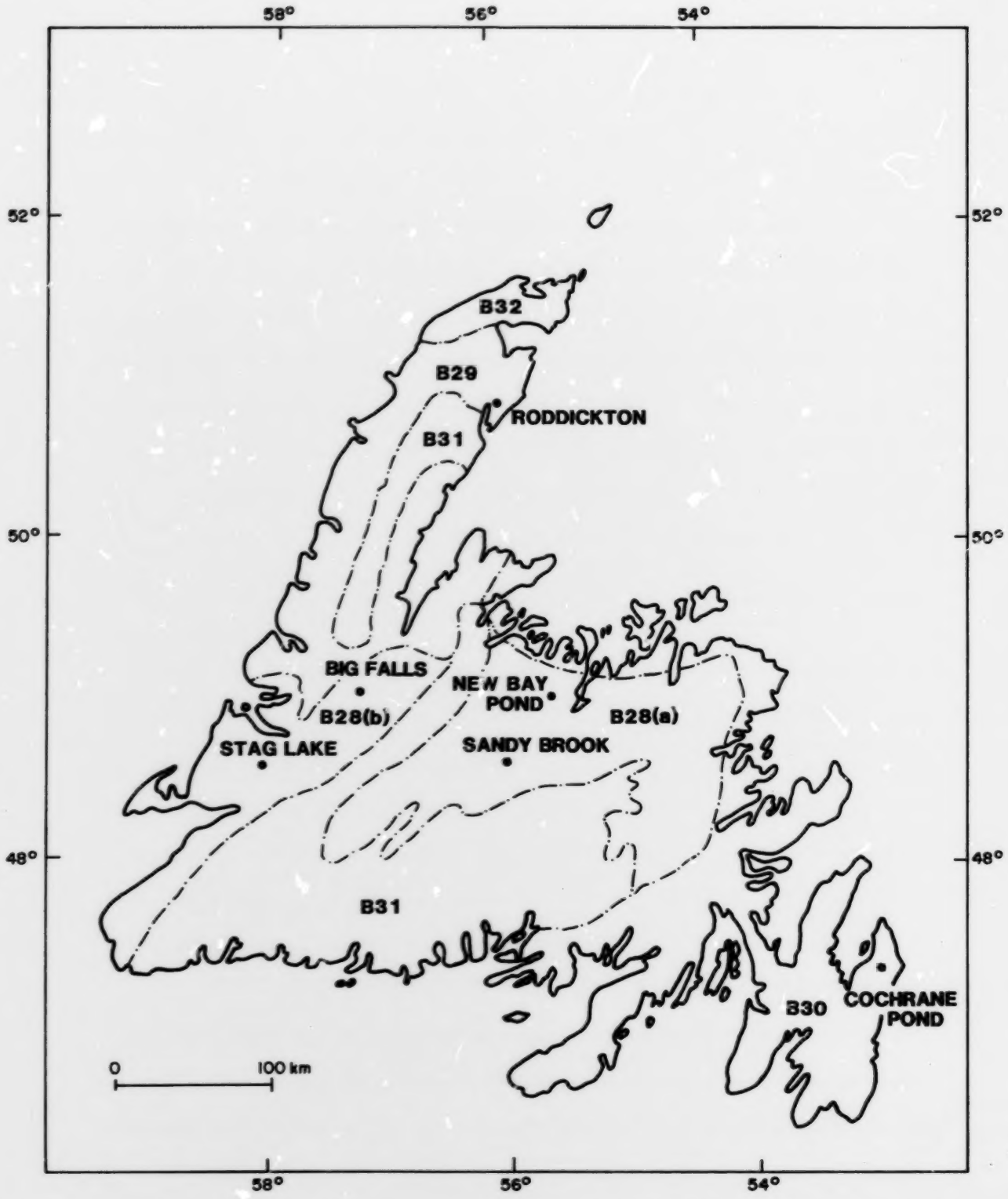

FIGURE 1. NEWFOUNDLAND SHOWING FOREST SECTIONS AND LOCATIONS OF BLACK SPRUCE PROVENANCE TRIALS

RESULTS AND DISCUSSION

Survival

Survival ranged from 67% at Stag Lake to 96.3% at Roddickton and was down only slightly from that reported five years previously (Table 2). The lowest survival and the greatest decrease between 10 and 15 years was recorded at Stag Lake. A dense cover of balsam fir [Abies balsamea (L.) Mill.] appeared to have suppressed many of the planted trees. Overall, plantation survival was inversely related to the degree of vegetative and slash competition on the site. Sites at Roddickton and Cochrane Pond had the best survival.

Table 2. Percentage survival 10 and 15 years from seed; 6 and 11 years from planting.

Plantation location	Percentage Survival		
	10 Years	15 Years	Range (15 Years)
Cochrane Pond	90.0	89.4	70.8 - 95.8
Roddickton	96.5	96.3	87.5 - 100
Stag Lake	74.7	67.0	45.8 - 83.3
Big Falls	90.6	88.3	75.0 - 100
Sandy Brook	86.8	82.8	62.5 - 100
New Bay Pond	78.9	75.0	62.5 - 91.7

Results from other provenance trials have indicated a higher survival of local provenances apparently because many were better adapted (Fowler and Park 1982). Such trends were not apparent in these plantations. There were no distinct trends in survival among provenances

or groups of provenances. However, since only 24 trees per provenance were tested the random loss of one tree represents a lowering of survival by 4.2% thus exaggerating any trends which might have been evident. Two sources (34, 36) from Prince Edward Island were from latitudes south of those of the plantations, and had lower than average survival in two plantations; but generally no correlation of survival with seed origin was apparent. It can thus be concluded that all seed sources are more or less well adapted to the planting sites. However, it is also possible that the latitudinal range of planting sites (3°30') and sources of provenances (7°43') may not be great enough to show clinal trends strong enough to affect survival.

Height Growth

The height of each provenance in each plantation is given in Appendix II. Height differed significantly among provenances in all six plantations. Variation among replicates was significant in four of the six plantations, Stag Lake and Sandy Brook excepted. In the four plantations the replication variance was greater than that among provenances. This was observed for these plantations at age 10 (Khalil 1981) and for other black spruce provenance trials (Segaran 1979, Boyle 1985).

There was a wide variation in the ranking from one plantation to another (Appendix II). This indicates that seed sources are not entirely independant of location (an analysis of variance of provenances common to all locations showed the interaction to be on the borderline of

significance at P = 0.95). If the original seed sources were from several trees there should be enough variability to adapt to most sites and the provenances would adapt differently to different sites. It is still possible to select high yield sources if they are stable over several environments (Morgenstern 1982). Causes of interactions have been attributed to differences between environment of origin and that of the plantation (differences in photoperiod, thermoperiod or soil types) and in variability in the adaptability levels of the provenances (Morgenstern 1982). The differences between origin and plantation are small in this trial thus explaining the low level of interaction present.

Provenances in the top quartile for height vary from site to site but several are common at two or more sites (Table 3). Over half the provenances (20 of 37) are in the top quartile at a minimum of one location; two (10 and 36) are in this group at five locations and three (20, 24, 37) at three locations. Four provenances (13, 21, 25, 43) are in the top quartile at two locations and the remainder at one plantation. There appears to be, therefore, a large number of provenances suitable for use on various sites. There is no trend of superiority (or inferiority) for "local" provenances and no identifiable group consistently performs well. Similar results were reported by Fowler and Park (1982). Two of the provenances in the top quartile (#10 - Frenchman's Cove, Nfld. and #36 - Queen's County, P.E.I.), show superiority in height growth but have no other common traits.

Table 3. Provenances in best quartile for each plantation.

Rank	Provenance No.	For. Sec.	Height (cm)	% of Mean	Rank at Age 10	Provenance No.	For. Sec.	Height (cm)	% of Mean	Rank at Age 10
		Cochrane Pond - B.30						Roddickton - B.29		
1	10	B.28b	208	114.9	3	20	B.28a	206	115.9	1
2	13	B.28b	196	108.3	2	23	B.28a	201	113.3	2
3	43	L.4a	194	107.0	7	15	B.28b	194	109.4	6
4	36	A.8	193	106.5	6	10	B.28b	194	109.1	8
5						14	B.28b	190	107.0	7
6						36	A.8	188	106.3	17
7						31	B.12	186	104.8	11
8						24	B.28a	186	104.7	5
9						22	B.28a	183	103.4	9
Mean			181					177		
		Stag Lake - B.28b						Big Falls - B.28b		
1	36	A.8	276	122.7	3	20	B.28a	247	121.1	1
2	37	A.3	267	118.9	6	21	B.29	238	116.9	2
3	25	B.28a	263	117.3	2	37	A.3	234	114.9	5
4	24	B.28a	263	117.0	9	23	B.28a	232	113.5	3
5	39	A.3	261	116.1	5	10	B.28b	220	108.0	6
6	28	B.30	240	106.9	14					
7	21	B.29	239	106.3	16					
Mean			225					204		
		Sandy Brook - B.28a						New Bay Pond - B.28a		
1	33	L.4c	209	151.3	1	37	A.3	164	127.0	2
2	43	L.4a	183	131.3	2	26	B.30	153	118.8	4
3	29	B.30	181	131.2	5	36	A.8	150	116.5	7
4	18	B.28a	166	119.8	4	10	B.28b	146	113.5	3
5	24	B.28a	163	118.2	3	13	B.28b	132	102.6	13
6	20	B.28a	158	114.7	6					
7	36	A.8	157	113.5	27					
8	25	B.28a	154	111.5	10					
9	10	B.28b	152	109.6	12					
Mean			138					125		

Considering the mainland provenances, the two from Labrador have not performed well after being moved south. One from Goose Bay (31) was in the top quartile at the most northerly site but performed poorly elsewhere. Of the other seven provenances five were in the superior group and of the two others one is from Queen's County, P.E.I. (34), the other from Caledonia, Nova Scotia (32). Stand to stand variation may show irregular patterns because these sources are from areas where black spruce stands are small and the possibility of inbreeding is high (Fowler and Park 1982). This explanation does not account for the excellent performance of the other Prince Edward Island seed source (36).

The trees, at 15 years are about one-fourth of the way through a rotation and there is now some indication of the suitability of these provenances, as many of them were also in the top quartile at age 10. The largest inter-provenance differences occurred at Sandy Brook (151.3%) and the smallest at Cochrane Pond (114.9%) and Roddickton (115.9%) (Table 3). To enable seed sources to be evaluated at an early stage it is necessary to determine if growth at an early age is correlated with growth at later stages. Heights were highly correlated in the nursery stage at ages two and four (Table 4). Since the provenances grow in different environments after outplanting this relationship often disappears. Correlation between ages 10 and 15 are very high in four of the six plantations. The slow growth rate and poor correlations at Sandy Brook and New Bay Pond indicates that the trees are under stress and that

Table 4. Correlation of height at different ages, all provenances, all plantations.[a]

Age	Age 4	Age 10	Age 15	Age	Age 4	Age 10	Age 15
		Cochrane Pond				Roddickton	
2	.959	.289*	.327	2	.895	(.081)	.201
4	-	.289*	.324	4		.253	.208
10	-		.819	10			.771
		Stag Lake				Big Falls	
2	.952	.533	.545	2	.948	.417	.552
4		.554	.660	4		.271	.438
10			.771	10			.920
		Sandy Brook				New Bay Pond	
2	.894	(.078)	.472	2	.948	(.083)	.315
4		.245	.554	4		.281	.360
10			.276	10			.488

[a]Figures in parentheses are not significant at P = 0.95, those followed by an asterisk are significant at P = 0.95, all others are significant at P = 0.99.

provenance effects are masked. There has been a wide change in rankings between ages 10 and 15 but the ones in the top quartile have not been much affected. Most changes in ranking occurred among the slower growing provenances.

Results from other provenance trials have shown high correlation of heights over time in Norway spruce (P. abies L.) (Baldwin et al. 1973) in white spruce (Ying and Morgenstern 1979) and black spruce

(Fowler and Park 1982, Boyle 1985). Boyle (1985) found that some provenances changed rank widely over time and some were stable over time and from one site to another. Similar results were found in the Newfoundland trials suggesting that early selection of superior provenances is possible. However, since the seed was formed under different conditions from those under which it was germinated and grown in the nursery and in the field, separation of the environmental and genetic effects is difficult (Rowe 1964).

There is a strong correlation between seed weight and early growth in the nursery (Table 5). This correlation is reduced when the seedlings are out-planted in their different environments making seed weight unreliable as an early predictor of subsequent growth.

There was evidence of a clinal trend of height growth with latitude but not longitude or elevation (Table 6). Correlations were low at Roddickton, the site with the most northerly latitude and extreme climate. Here the climate had more effect on growth than these factors and here the pattern of variation is ecotypic. This has been reported previously (Khalil 1973). In the more southerly plantations, there is a decline in growth with latitude, typical for seed sources of northerly origin. This indicates clinal variation in black spruce as has been reported by Morgenstern (1969) and Fowler and Park (1982). The data suggest clinal trends in Newfoundland, except for Roddickton and Cochrane Pond suggesting that local climate-driven selection pressures have resulted in some ecotypic variation in these two areas. Boyle (1985)

Table 5. Correlation(s) of height and seed weight at various ages.

Age	Correlation Coefficients at - Cochrane Pond	Roddickton	Stag Lake	Big Falls	Sandy Brook	New Bay Pond
2	.598	.608	.585	.589	.607	.601
4	.608	.601	.591	.604	.603	.615
10	(.019)[a]	(-.057)	.384	.207*	(-.064)	(-.063)
15	(.143)	(-.053)	.352	.256*	.313	.379

[a]Figures in parentheses are not significant at P level 0.95;
*significant at P = 0.95, remainder are significant at P = 0.99.

Table 6. Correlation(s) of height and factors of the origin of provenances at age 10 and 15.

Location	Correlation Coefficients for - Latitude (°N) 10	15	Longitude (°W) 10	15	Elevation (m) 10	15
Cochrane Pond	.142	-.191	-.118	.148	.164	.244*[a]
Roddickton	.038	.011	.107	-.147	-.086	-.072
Stag Lake	-.534**	-.617**	.216*	.191*	.053	-.080
Big Falls	-.129	-.322**	-.108	.101	-.107	-.005
Sandy Brook	-.463**	-.407**	.482**	.470**	.465**	.381**
New Bay Pond	-.128	-.411**	-.063	.243*	-.072	-.219*

[a]*Significant at P = 0.95; **significant at P = 0.99; others not significant at P = 0.95.

suggested that clinal effects would decline with age but this has not happened in the Newfoundland tests. The trees are smaller at age 15 than those measured in Boyle's study, and this may account for the dissimilar results.

Overall there are distinct indications that black spruce is an adaptable species because of the high survival rates for most provenances on the majority of sites tested. Recent studies on response of black spruce to soil fertility have shown that it is a broadly adaptable and flexible species (Mullin 1985, Maliondo and Krause 1985). Since local sources in the Newfoundland tests are not always best, it suggests that black spruce may not be optimally adapted to sites which it now occupies, and that adaptability for survival and for height may require different mechanisms.

CONCLUSIONS

1. Variation in height growth of black spruce in Newfoundland is both clinal and ecotypic. Clinal variation dominates in most of insular Newfoundland except for the Northern Peninsula (For. Sec. B.29) and the Avalon Peninsula (For. Sec. B.30).
2. Black spruce is broadly adapted to all sites tested for survival and growth.
3. Seed sources are recommended for reforestation use in the different forest zones of the Island based upon their height growth. The results show high correlation between height at ages 10 and 15 years.

Two sources are recommended for five locations:

Provenances	Locations
10 - Frenchman's Cove	- Cochrane Pond, Roddickton, Big Falls, Sandy Brook, New Bay Pond
36 - Queen's Co., P.E.I.	- Cochrane Pond, Roddickton, Stag Lake, Sandy Brook, New Bay Pond

Three sources are recommended for three locations:

Provenances	Locations
20 - Bishop's Falls	- Roddickton, Big Falls, Sandy Brook
24 - North Pond	- Roddickton, Stag Lake, Sandy Brook
37 - Acadia FES, N.B.	- Stag Lake, Big Falls, New Bay Pond

Several other sources performed well enough to be recommended for one or two locations (Table 3).

4. Trees are only 15 years old, constituting only one-fourth of a rotation, and although age:age correlations are high, local seed sources should continue to be used in reforestation (in addition to those stated above) to maintain a broad genetic base. Sources performing well should be tested in other locations.

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Appendix I. Seed sources for black spruce provenance trials.[a]

Provenance Number	Location	Latitude (N)	Longitude (W)	Elevation (m)	Forest Section[b]
1	Pistolet Bay	51°29'	55°42'	15	B.32
2	Plum Point	51°03'	56°46'	60	B.29
3	Roddickton	50°52'	56°07'	15	B.29
4	Hawke's Bay	50°34'	57°16'	60	B.29
5	Harbour Deep	50°24'	56°28'	3-60	B.29
6	Fleur-de-Lys	50°06'	56°10'	150	B.29
7	Baie Verte Jct.	49°27'	56°28'	60	B.29
8	Lomond	49°25'	57°45'	90-120	B.28b
10	Frenchman's Cove	49°03'	58°12'	90	B.28b
11	Pinchgut Lake	48°48'	58°04'	180	B.28b
13	Piccadilly	48°34'	58°55'	30	B.28b
14	Point au Mal	48°36'	58°41'	60	B.28b
15	Bottom Brook	48°34'	58°11'	75	B.28b
16	South Branch	47°54'	59°03'	60	B.28b
17	Gull Pond	49°11'	56°06'	180	B.28a
18	Millertown	48°50'	56°29'	180	B.28a
19	Victoria Lake	48°27'	57°00'	300	B.28a
20	Bishops Falls	49°01'	55°26'	60	B.28a
21	Davidsville	49°22'	54°25'	30	B.29
22	Greenwood Brook	48°42'	55°11'	150	B.28a
23	NW Gander River	48°40'	55°14'	120	B.28a
24	North Pond	48°42'	54°27'	90	B.28a
25	Port Blandford	48°24'	54°12'30"	60	B.28a
26	Swift Current	47°55'	54°15'	15	B.30
27	Epworth	47°01'	55°14'	90	B.30
28	Placentia	47°13'	53°52'30"	60	B.30
29	St. John's	47°30'	52°51'30"	150	B.30
30	Pinware River, Labrador	51°42'	56°41'	30	B.16
31	Goose Bay, Labrador	53°25'	60°23'	3	B.12
32	Caledonia, Nova Scotia	45°18'	62°24'	-	A.11
33	Petawawa For. Exp. Sta., Ont.	45°58'	77°25'	160	L.4c
34	Farmington, P.E.I.	47°	62°	20	A.8
36	Queen's Co., P.E.I.	46°	62°	30	A.8
37	Acadia FES, N.B.	46°01'	66°21'	80	A.3
39	Camp Gagetown, N.B.	45°42'	66°32'	15	A.3
43	Valcartier, P.Q.	46°54'	71°30'	600	L.4a
44	Bottom Brook	48°34'	58°11'	300	B.28b

[a]Site description Nicholson and Tricco 1969.

[b]Newfoundland and Labrador only.

Appendix II. Mean height, all plantations, all provenances and range test at age 15.

	Provenance - 1. Cochrane Pond				Provenance - 2. Roddickton			
Rank	No.	For. Sec.[a]	Height (cm)	Test[b]	No.	For. Sec.	Height (cm)	Test
1	10	B.28b	208		20	B.28a	206	
2	13	B.28b	196		23	B.28a	201	
3	43	L.4a	194		15	B.28b	194	
4	36	A.8	193		10	B.28b	193	
5	16	B.28b	189		14	B.28b	190	
6	6	B.29	186		36	A.8	188	
7	24	B.28a	185		31	B.12	186	
8	7	B.29	183		24	B.28a	186	
9	19	B.28a	180		22	B.28a	183	
10	26	B.30	178		26	B.30	183	
11	20	B.28a	176		28	B.30	183	
12	28	B.30	173		21	B.29	182	
13	3	B.29	167		2	B.29	182	
14	7	B.29	159		8	B.28b	182	
15	34	A.8	152		7	B.29	182	
16					25	B.28a	180	
17					32	A.11	179	
18					17	B.28a	179	
19					43	L.4a	178	
20					33	L.4c	178	
21					19	B.28a	177	
22					3	B.29	176	
23					39	A.3	176	
24					4	B.29	173	
25					1	B.32	173	
26					16	B.28b	169	
27					27	B.30	167	
28					44	B.28b	167	
29					13	B.28b	166	
30					18	B.28a	165	
31					5	B.29	164	
32					11	B.28b	161	
33					6	B.29	160	
34					34	A.8	156	
35					37	A.3	155	
36					30	B.16	154	

..../Cont'd.

Appendix II. (Cont'd.)

Rank	Provenance - 3. Stag Lake				Provenance - 4. Big Falls			
	No.	For. Sec.[a]	Height (cm)	Test[b]	No.	For. Sec.	Height (cm)	Test[b]
1	36	A.8	276		20	B.28a	247	
2	37	A.3	267		21	B.29	238	
3	25	B.28a	263		37	A.3	234	
4	24	B.28a	263		23	B.28a	232	
5	39	A.3	261		10	B.28b	220	
6	28	B.30	240		15	B.28b	219	
7	21	B.29	239		44	B.28b	216	
8	20	B.28a	238		28	B.30	211	
9	44	B.28b	238		36	A.8	211	
10	7	B.29	237		43	L.4a	206	
11	4	B.29	236		7	B.29	203	
12	19	B.28a	232		34	A.8	203	
13	34	A.8	229		26	B.30	193	
14	13	B.28b	222		6	B.29	193	
15	10	B.28b	222		13	B.28b	183	
16	26	B.30	218		24	B.28a	180	
17	8	B.28b	217		4	B.29	180	
18	15	B.28b	212		16	B.28b	174	
19	43	L.4a	212		19	B.28a	173	
20	6	B.29	211		1	B.32	154	
21	18	B.28a	207					
22	23	B.28a	198					
23	16	B.28b	190					
24	5	B.29	183					
25	3	B.29	175					
26	30	B.16	168					

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Appendix II. (Concl'd.)

Rank	Provenance - 5. Sandy Brook				Provenance - 6. New Bay Pond			
	No.	For. Sec.[a]	Height (cm)	Test[b]	No.	For. Sec.	Height (cm)	Test[b]
1	33	L.4c	209		37	A.3	164	
2	43	L.4a	183		26	B.30	153	
3	29	B.30	181		36	A.8	150	
4	18	B.28a	166		10	B.28b	146	
5	24	B.28a	163		13	B.28b	132	
6	20	B.28a	158		4	B.29	130	
7	36	A.8	157		7	B.29	128	
8	25	B.28a	154		6	B.29	128	
9	10	B.28b	152		24	B.28a	125	
10	17	B.28a	151		28	B.30	123	
11	13	B.28b	148		19	B.28a	121	
12	34	A.8	145		20	B.28a	119	
13	37	A.3	142		43	L.4a	118	
14	15	B.28b	140		23	B.28a	117	
15	7	B.29	139		16	B.28b	116	
16	16	B.28b	139		3	B.29	105	
17	14	B.28b	138					
18	4	B.29	138					
19	23	B.28a	137					
20	19	B.28a	137					
21	26	B.30	136					
22	6	B.29	136					
23	11	B.28b	135					
24	39	A.3	132					
25	21	B.29	132					
26	44	B.28b	129					
27	3	B.29	129					
28	31	B.12	128					
29	27	B.30	124					
30	8	B.28b	123					
31	1	B.32	122					
32	32	A.11	121					
33	2	B.29	115					
34	22	B.28a	108					
35	28	B.30	107					
36	30	B.16	99					
37	5	B.29	96					

[a]Forest Section (Rowe 1972).

[b]Duncan's New Multiple Range Test (Steel and Torrie 1960).